

^{1,2}Shuang Wang¹ Lu Liu^{2,3}Xin Xie^{1,*}Lingling Zhang^{1,*}Yimin Zheng

Spatial and Temporal Distribution and Flow Characteristics of High-Quality Development of Modern Service Industry in Chinese Sub-provincial Cities



Abstract: - Based on the new development concept of the service industry, this paper constructs a comprehensive evaluation index system for the high-quality development of modern service industry from a total of 22 indicators in four dimensions, namely, development efficiency, structural optimization, innovation agglomeration and industrial scale. The composite index of 15 sub-provincial cities in China from 2013 to 2022 was measured by entropy weight method, describing the current development status and development differences of each city, and with the help of Kernel density estimation method and Dagum Gini coefficient method, the law of inter-city evolution was inscribed, which revealed the spatial differences of the four major geographic regions and their sources and contributions. The study shows that the overall high-quality development of the service industry in the 15 cities is at a relatively low level, with obvious differences, but all of them are on a slowly rising trend. According to the division of the four major geographic regions, the northeast region has the largest intra-regional differences, and the eastern region has the smallest intra-regional differences. Meanwhile, the spatial imbalance between regions is still aggravating, and there is a clear differentiation between the development level of the eastern and western regions.

Keywords: Modern Services; High Quality Development; Kernel Density Estimation; Dagum Gini Coefficient

I. INTRODUCTION

Since the reform and opening up, China's service industry has experienced a historic leap from scratch, from small to large, and from weak to strong, with not only the scale continuing to expand, but also the structure continuously optimized, and the contribution rate to economic growth increasing year by year. However, compared with developed countries, China's service industry still has a big gap in terms of service quality, innovation capacity and internationalization level, and faces many challenges in high-quality development. President Xi Jinping emphasized in his report to the 20th Congress of the Communist Party of China (CPC) that "a new system of high-quality and high-efficiency services is being built, and the deep integration of modern services with advanced manufacturing and modern agriculture is being promoted. High-quality development is the primary task of building a modernized socialist country in an all-round way." Therefore, promoting the high-quality development of the modern service industry is not only an objective need to adapt to the development trend of the global economy, but also an intrinsic requirement to realize economic transformation and upgrading, and enhance international competitiveness. At present, China's economy has entered the stage of high-quality development, comparing with international advanced experience, accelerating the high-quality development of modern service industry is the focus of China's current work. Taking this as a guide, scientifically constructing an evaluation index system for the high-quality development of modern service industry, objectively analyzing the characteristics of temporal and spatial development as well as the evolution trend, and proposing countermeasures to address the problems are of great theoretical and practical significance for promoting the high-quality and coordinated development of modern service industry.

II. LITERATURE REVIEW

Regarding the theoretical research on the high-quality development of the service industry, some scholars believe that the development of the service industry should be based on the concept of innovation, coordination, green, openness and sharing, for the advantages and shortcomings of the service industry, adhere to the development of innovation, aim at the weaknesses, according to the local conditions, and take the road of differentiated high-quality development; at the same time should be optimized for the service industry industry

¹ College of Economics and Management, Dalian University, Dalian 116622, China

² Graduate School, Lyceum of the Philippines University, Manila 1002, Philippines

³ Zhangzhou Institute of Technology, Zhangzhou363000, China

*Corresponding author: Lingling Zhang, College of Economics and Management, Dalian University, Dalian 116622, China

Email: zhanglingling1@dlu.edu.cn;

Yimin Zheng, College of Economics and Management, Dalian University, Dalian 116622, China

Email: zhengyimin@dlu.edu.cn

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management system, the supply of high-end talents, and the degree of openness to the outside world. Y. W. Lai through the elaboration of high-quality development of the service industry facing the problem, put forward should relax market access restrictions, improve the regulatory system and other requirements [1]; High-quality development of the service industry is the cornerstone of the sustainable development of the economy, J. C. Xia based on the experience of Zhejiang Province, that high-quality development of the service industry not only can narrow the gap between the regional development of this region, but also narrow the gap between the development of neighboring regions, help to accelerate the optimization of the structure and upgrading of the service industry, and steadily promote the process of urbanization [2].

Regarding the construction of an indicator system to measure high-quality development, most scholars at this stage focus on the five development concepts put forward by the Party in the Fifth Plenary Session of the 18th Central Committee to build an indicator system. X. Liu sets up an indicator system from six aspects, including economic growth, coordinated development, innovative development, green development, open development and shared development, to explore the impact of the service industry on high-quality economic development and its spatial effect [3]; G. J. Hu also believes that it is necessary to highlight the new development concept, take innovation, coordination, green, development and sharing as the index system, and use the entropy weight method to measure and analyze the level of high-quality development of the service industry in the central region [4]; There is also part of the literature that adopts a single indicator, such as Z. M. Li, who explores the high-quality development of the service industry in terms of the output and input terms [5], but it is difficult to react to the multidimensional characteristics of the high-quality development of the service industry. However, it is difficult to reflect the multidimensional characteristics of high-quality development of the service industry. Based on this, this paper is committed to seeking improvements and breakthroughs, in-depth research and exploration of the connotation and characteristics of high-quality development of the service industry, so as to build a new perspective of the evaluation index system of high-quality development of modern service industry.

Regarding the statistical measurement aspect of the high-quality development of the service industry. Some scholars use the entropy weight method to evaluate the high-quality development of the modern service industry, G. J. Hu analyzed the high-quality development level of the service industry in six provinces during nine years under the framework of the industrial level by using the entropy weight method, which provides inspiration for the implementation of differentiated development in each province [4], and the research method is relatively singular; J. H. Chen also uses the entropy weight method as the basic method to calculate the objective and reliable comprehensive index value, which provides the analysis of the subsequent evolutionary trends with theoretical support [6]. Some scholars have also used the Dagum [7] Gini coefficient and its decomposition to reveal the essential reasons for the differences in the development of an industry among regions, through which B. Y. Zhang argues that the main cause of regional disparities in the high-quality development of China's logistics industry is the inter-regional disparity [8]; C. C. Yan similarly uses the Dagum Gini coefficient method to conduct a comparative analysis of regional differences in the level of economic development of the platforms and the inter-provincial differences [9]. As for the trend evolution measurement study of industry development, scholars such as Z. M. Li reveal its spatial convergence trend with the help of spatio-temporal β -convergence model, but the spatio-temporal β -convergence model is built on certain assumptions, which may not be fully in line with the complexity of the real world, and thus has certain drawbacks. While B. Y. Zhang, J. L. Gao and other scholars use the Kernel density estimation method to describe the inter-regional distribution dynamics with continuous density curves to effectively analyze the spatial and temporal changes in the high-quality development of the industry [8]; In terms of spatial division, most scholars divide the region according to the region, such as the east, central and west; Some scholars have also subdivided the region into eight economic zones: northeast, north coast, east coast, south coast, middle reaches of the Yellow River, middle reaches of the Yangtze River, the Great Southwest, and the Great Northwest, and how to divide the space depends on the needs of the research topic selection, and also depends on the situation of the differences between the regions, which facilitates the study of the subsequent evolution of the trend [10].

To summarize, in terms of research objects, the existing literature mostly explores the high-quality development of the service industry in terms of the strengths and weaknesses of the service industry, and the impact of individual factors on the national service industry, failing to focus on the dynamics over a period of time or the horizontal differences in the service industry between regions. There are 15 sub-provincial cities in China (Dalian, Haerbin, Changchun, Shenyang, Xi'an, Wuhan, Shenzhen, Xiamen, Qingdao, Ningbo, Nanjing, Jinan, Hangzhou, Guangzhou, and Chengdu), which, as the center cities of each economic region, have certain representativeness and universality. Studying these cities will help this paper to distill from them the conclusions and inspirations of

general significance, which can provide lessons and references for the development of the service industry of neighboring regions and promote regional coordination. It can provide lessons and references for the development of service industry in the neighboring regions and promote the coordinated development of the region. In terms of research methods, the entropy weight method can make the final decision-making results more real and reliable, the Dagum Gini coefficient and its decomposition method can identify the spatial disparities and their trends in each region on the basis of avoiding the problem of data cross-over overlap, and the Kernel density estimation method describes the inter-region distribution dynamics with continuous density curves, which has strong stability. The use of a single measurement method is likely to lead to objective bias in data quality, while the combination of the three methods enables this paper to explore and innovate more in the high-quality development of the service industry.

Based on this, the research on the high-quality development of modern service industry in this paper will be carried out in the following aspects: ① Construct the evaluation index system of high-quality development of modern service industry, and measure and analyze the level of high-quality development of service industry of 15 sub-provincial cities during 2013-2022; ② Use the Kernel density estimation method to characterize the dynamic evolution of the high-quality development of modern service industry in 15 sub-provincial cities; ③ With the help of Dagum's Gini coefficient and its decomposition method, measure the spatial differences in the level of high-quality development of the modern service industry and decompose them, so as to reveal the sources of the differences and their contributions.

III. RESEARCH DESIGN

A. Construction of an evaluation indicator system

This paper is guided by Xi Jinping's thought of socialism with Chinese characteristics in the new era, adheres to the new development concept, deepens the supply-side structural reform of the service industry, builds an indicator system, and promotes the development of the service industry in the direction of higher quality, more efficient, and more sustainable.

The benefits of development are most directly reflected in the growth of economic efficiency. By optimizing the allocation of resources and improving the efficiency and quality of services, the service industry can create more economic value and promote the sustained and healthy development of the economy. This paper assesses the level of development effectiveness of the high-quality development of the modern service industry from the aspects of total development and development speed.

Structural optimization helps to enhance the core competitiveness of the service industry. Structural optimization means that the industry chain within the service industry is more complete, the connection between various links is closer, and in terms of industry layout and resource allocation, the proportional relationship between various industries is optimized according to the market demand to form complementary advantages. Therefore, this paper assesses the level of structural optimization of the high-quality development of the modern service industry from two aspects: regional structure and industrial structure.

Innovation agglomeration is an important symbol of the high-quality development of the service industry. Enterprises, research institutes and universities form a close cooperation network to carry out technological innovation together, which helps to promote the high-end and intelligent development of the industry, thus enhancing the competitiveness of the service industry. Therefore, this paper assesses the level of innovation agglomeration in the high-quality development of modern service industry from three aspects: scientific and technological input, scientific and technological output, and future development.

The expansion of the industry's scale most directly reflects the growth of the total economic volume of the service sector. As the value-added of the service industry continues to rise as a proportion of GDP, it implies the rapid development of the service industry and shows that its contribution to the overall economy is increasing. Therefore, the expansion of the industry helps to promote social stability. This paper assesses the level of industrial scale for the high-quality development of the modern service industry from this aspect.

This paper considers that the high-quality development of modern service industry is a state of development with both development efficiency, structural optimization, innovation agglomeration and industrial scale, and based on this, it designs a total of 22 specific indicators in 4 dimensions to scientifically evaluate the level of high-quality development of modern service industry in each city and the regional gap. It also further analyzes the change rule and spatial and temporal differentiation characteristics of the high-quality development of the service industry in different regions from a spatial and temporal perspective, so as to provide reference for accelerating the high-

quality development of the modern service industry and promoting the coordinated development of the region. The indicator system is listed in Table 1.

Table 1. Evaluation index system for high-quality development of modern service industry

Level 1 indicators	Level 2 indicators	Level 3 indicators	Index quantification	Attribute		
Development benefits	Total development	GDP	GDP (100 million yuan)	+		
		Value added of service industry	Value value of service industry (100 million yuan)	+		
		The number of new service industry enterprises	Number of new service industry enterprises (home)	+		
		Total retail sales of social consumer goods	Total retail sales of social consumer goods (ten thousand yuan)	+		
		Annual annual GDP growth rate	(1 + average annual growth rate) n = current / base period (%)	+		
	speed of development	The average annual growth rate of total retail sales of consumer goods	(1 + average annual growth rate) n = current / base period (%)	+		
		The added value of the service sector grew annually	(1 + average annual growth rate) n = current / base period (%)	+		
		Labor productivity in the service industries	added value of service industry / employment of service industry (100 million yuan / person)	+		
		optimum structure	domain structure	The proportion of the added value of the service sector in the regional GDP	The added value of the services sector / GDP (%)	+
				The proportion of the service industry employees in the whole society	Service sector employees / total employment: (%)	+
industrial structure	The ratio of the added value of the tertiary industry and the secondary industry		The added value of the tertiary industry / the added value of the secondary industry is (%)	+		
Innovation agglomeration	science and technology input	R & d investment intensity	R & D investment / GDP: (%)	+		
	Technology output	Invention patent authorization situation	Authorization of invention patent (piece)	+		

		Acceptance of applications for invention patents	Acceptance of the application for invention patent (piece)	+
		The number of invention patent applications accepted per 100,000 people accepted	Acceptance of invention patent application / total population of the region (piece / 10,000)	+
	future development	Agglomeration degree of the service industry	Number of new service enterprises / total population (family / 10,000)	+
		The added value of the financial industry accounts for the proportion of the regional GDP	Financial sector value added / GDP (%)	+
		The added value of transportation, storage and postal services accounted for the proportion of the regional GDP	added value of total logistics cost / GDP (%)	+
		The added value of wholesale and retail sales accounted for the proportion of regional GDP	Wholesale and retail total cost added value / GDP (%)	+
Industrial scale	Industrial scale	Total revenue from tourism	Total revenue of tourism (100 million yuan)	+
		The added value of accommodation and catering industry accounted for the proportion of regional GDP	Added of accommodation and catering industry / GDP (%)	+
		The added value of the real estate industry accounts for the proportion of the regional GDP	added value of real estate / GDP (%)	+

B. Research methodology

1) Entropy weight method

Entropy weight method an objective empowerment method, according to the degree of dispersion of data, effectively overcome the influence of subjective factors, so as to obtain objective evaluation results. The specific steps are as follows:

(a)Standardized treatment:

$$r_{ij} = \frac{x_{ij} - \min\{x_{ij}\}}{\max\{x_{ij}\} - \min\{x_{ij}\}}$$

(b)Calculate the information entropy e_j for the j th indicator:

$$e_j = -k \sum_{i=1}^n \left(\frac{r_{ij}}{\sum_{i=1}^n r_{ij}} \right) \ln \left(\frac{r_{ij}}{\sum_{i=1}^n r_{ij}} \right)$$

Among them, $k = \ln n$

(c) Calculation of indicator weights:

$$w_j = \frac{(1 - e_j)}{\sum_{j=1}^m (1 - e_j)}$$

(4) Calculation of a composite index of high-quality development of the service sector in each region:

$$I = \sum_{j=1}^m r_{ij} w_j$$

2) Kernel density estimation

Kernel density estimation method can estimate the probability density of a random variable and describe its distribution trend with continuous density curve, which has strong stability. This paper adopts Gaussian kernel function to study the distribution dynamics of the composite index of high-quality development of modern service industry in 15 sub-provincial cities.

$$f(x) = \frac{1}{Nb} \sum_{i=1}^N k\left(\frac{x_i - x}{h}\right)$$

$$k(x) = \frac{1}{\sqrt{2\pi}} \exp\left(-\frac{x^2}{2}\right)$$

Where: $f(x)$ is the density function of the high quality development level x of the modern service industry; N is the number of samples; x_i is the independently distributed sample value; x is the mean of the sample value; h is the bandwidth, and the estimation accuracy is inversely proportional to the size of the bandwidth.

3) Dagum's Gini coefficient and cohort decomposition methods

In this paper, the Gini coefficient decomposition method by subgroups proposed by Dagum [7] is used to examine the degree of spatial differentiation in the high-quality development of modern service industry, which effectively solves the problem of the source of spatial differentiation as well as the problem of cross overlap between sub-samples. The basic definition of the Gini coefficient is as follows: where: y_{ji} (y_{hr}) represents the comprehensive index of high-quality development of modern service industry in the j th (h) city; μ ($\mu_h \leq \mu_j \leq \dots \leq \mu_k$) represents the mean value of the comprehensive index of high-quality development of modern service industry in all the cities contained in a certain geographic area; k represents the number of geographic areas; n represents the number of cities; n_j (n_h) represents the number of cities contained in the j th (h) geographic region.

$$G = \frac{\sum_{j=1}^k \sum_{h=1}^k \sum_{i=1}^{n_j} \sum_{r=1}^{n_h} |y_{ji} - y_{hr}|}{2n^2\mu}$$

C. Data sources

In this paper, 15 sub-provincial cities in China are taken as the research samples, and the data are mainly obtained from China Statistical Yearbook from 2013 to 2022, the official website of each city's Bureau of Statistics, the statistical bulletin of national economic and social development, and the statistical yearbook of each region, etc., in which some of the missing data are filled in by using the method of mean value and linear interpolation.

IV. SPATIAL AND TEMPORAL DISTRIBUTION OF THE HIGH-QUALITY DEVELOPMENT OF THE MODERN SERVICE SECTOR

A. Dynamic distribution of high-quality development of modern service industries

This paper utilizes the entropy weight method to measure the comprehensive index of the level of high-quality development of modern service industry in 15 sub-provincial cities in China from 2013 to 2022 (see Table 2 for details).

Table 2. Value of the composite index of high-quality development of the modern service sector, 2013-2022

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Dalian	0.36	0.54	0.46	0.44	0.59	0.54	0.56	0.38	0.43	0.45
Haerbin	0.34	0.42	0.37	0.48	0.52	0.42	0.43	0.29	0.38	0.47
Changchun	0.21	0.26	0.33	0.41	0.64	0.39	0.51	0.50	0.47	0.61
Shenyang	0.24	0.33	0.45	0.35	0.58	0.57	0.62	0.58	0.67	0.61
Xi'an	0.23	0.36	0.40	0.46	0.63	0.61	0.71	0.46	0.51	0.47
Wuhan	0.12	0.18	0.22	0.29	0.34	0.35	0.46	0.42	0.56	0.85

Shenzhen	0.32	0.39	0.44	0.59	0.49	0.50	0.61	0.45	0.55	0.50
Xiamen	0.19	0.21	0.19	0.30	0.33	0.34	0.56	0.39	0.47	0.70
Qingdao	0.17	0.27	0.33	0.42	0.52	0.56	0.55	0.59	0.66	0.62
Ningbo	0.19	0.17	0.40	0.32	0.39	0.43	0.62	0.53	0.58	0.58
Nanjing	0.25	0.32	0.36	0.42	0.49	0.49	0.66	0.61	0.75	0.68
Jinan	0.24	0.22	0.27	0.36	0.44	0.43	0.64	0.49	0.69	0.66
Hangzhou	0.17	0.24	0.29	0.40	0.45	0.48	0.67	0.63	0.69	0.72
Guangzhou	0.20	0.25	0.34	0.43	0.55	0.47	0.55	0.52	0.64	0.65
Chengdu	0.13	0.25	0.25	0.29	0.34	0.42	0.76	0.62	0.73	0.70

From the perspective of dynamic trends, all cities are in a small upward trend during the 10-year period; Among them, Dalian has the smallest increase during the period of 2013-2022, with the difference between the composite indexes of 2013 and 2022 being 0.086, and Haerbin is the second largest, with a difference of 0.134. And the biggest rise is Wuhan, the difference between the composite index in 2013 and 2022 is 0.733, which indicates that the dynamic growth trend of the service industry development in Dalian and Harbin has a large gap with other cities, the reason is that Dalian and Harbin, as the representative cities of the Northeast region, the pillar industries are mainly heavy industries represented by petroleum, chemical and shipbuilding industries, and transportation equipment, general equipment, electronic equipment as representative of the equipment manufacturing industry, the pillar industries did not provide sufficient impetus for the development of the service industry, making the reform of the service industry relatively lagging behind, with a lower degree of marketization, thus resulting in a smaller growth rate compared with other cities.

From the point of view of regional differences, this paper selects the comprehensive index value in 2020 and 2022 for comparison, see Figure 1. Overall, the average value of the comprehensive index of high-quality development of the service industry in each city in 2020 is 0.498, of which Hangzhou has the highest value of the comprehensive index of 0.631, followed by Chengdu and Nanjing, with the values of the comprehensive index of 0.618 and 0.609; Haerbin has the lowest composite index value of 0.286. In 2022, the average value of the composite index of high-quality development of the service industry in each city is 0.618, of which Wuhan has the highest value of the composite index, 0.852, followed by Hangzhou and Xiamen, with the values of the composite index of 0.717 and 0.701; Dalian has the lowest value of the composite index of 0.445. In summary, the composite index of the high-quality development of the service industry in each city in 2022 is higher than that in 2020. Among them, Wuhan City has the largest change trend, the composite index rose from 0.42 to 0.85, and the outbreak place of the new crown epidemic is the most important influencing factor. 2020 The blockade and restrictive measures of the epidemic led to a significant drop in patronage in the service sector, and many service businesses had to suspend operations or downsize, resulting in a reduction in service supply. At the same time, the epidemic has accelerated the digital transformation of the service sector, with many businesses beginning to adopt online service models to accommodate specific needs during the epidemic. And due to the special nature of the service industry, which requires face-to-face communication and service, employment in the service industry was also greatly affected during the epidemic, with many service workers facing the risk of unemployment and increased employment pressure. Among them, Wuhan, as the first city to be closed during the epidemic, suffered the greatest impact.

Despite the considerable impact of the epidemic on the service industry, the service industry is still actively coping and recovering. With the gradual control of the epidemic and the recovery of the global economy, the attention and support of the government and all sectors of society have provided a favorable environment and conditions for the development of the service industry, which has led to a substantial increase in the composite index of high-quality development of the service industry in all cities in 2022. The impact of the epidemic on the service industry is complex and far-reaching, bringing both challenges and opportunities.



Figure 1. Changing dynamics of high-quality development of modern services in 2020 and 2022

B. Differences in the composition of the high-quality development of modern service industries

Figure 2 shows the spatial gap in the high-quality development of the modern service industry for the four first-level indicators in 2022. Overall, the values of the four indicators fluctuate greatly, indicating that there are differences in the level of high-quality development of the service industry in various regions. The industry scale indicator is at a low level, with an average value of 0.381, indicating that the market demand for the products or services of the industry decreases, while with the economic development and industrial structure adjustment, some traditional industries may face the pressure of transformation and upgrading, in the process, there may be a short-term decline in the scale of the industry, but it will help the healthy development of the industry in the long run. Among them, Wuhan has the largest industrial scale index, 0.838, and Haerbin has the smallest industrial scale index, 0.182, with a significant gap, indicating that Wuhan, as an economically developed region in China, has a strong economic foundation, which provides a solid material basis for the development of the service industry; The structural optimization indicator as a whole is at a high level, with an average value of 0.825, indicating that the service industry of each city has been in a state of continuous development, occupies a favorable position in the market, and has a high status and contribution in the national economy. Therefore, there are obvious spatial differences in the level of high-quality development of modern service industry in each region, and promoting high-quality development of service industry and synergizing balanced regional growth are two important issues in city construction.

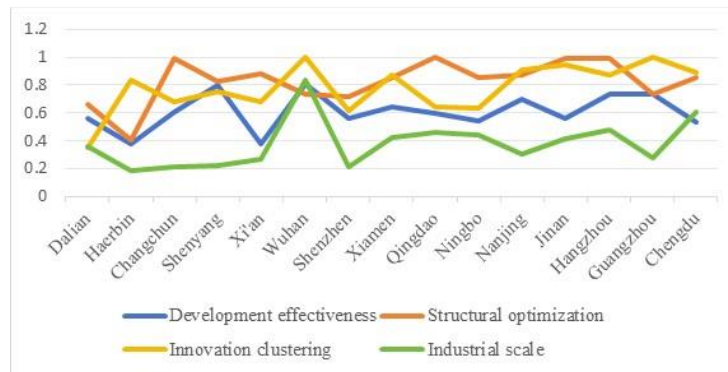


Figure 2. Spatial gaps in the high-quality development of the modern services sector for the four first-level indicators in 2022

V. DYNAMIC EVOLUTIONARY CHARACTERISTICS OF THE HIGH-QUALITY DEVELOPMENT OF MODERN SERVICE INDUSTRIES

In order to continue to explore the evolutionary characteristics and laws of the high-quality development of the modern service industry in each city, this paper analyzes the characteristics of the distribution location, morphological changes and polarization phenomenon of the high-quality development level of the service industry in the sub-provincial cities with the help of the Kernel density estimation method, as shown in Figure 3.

First of all, from the position of distribution, the high-quality development of the service industry in the 15 sub-provincial cities showed a rightward shift, then a leftward shift and then a rightward shift, with a fluctuating trend of "upward-declining-upward", indicating that the level of high-quality development of the modern service industry of each city is gradually rising; The distribution of the level of high-quality development of modern service industry fluctuates from left to right, which may be due to the higher degree of openness of sub-provincial cities to the outside world, and is affected by the many uncertainties faced by the development of the world economy; in terms of sub-cities, the trend of rightward shift of the northeastern cities, led by Dalian and Haerbin, is significantly smaller than the rest of the cities, which presumably indicates that the level of high-quality development of the modern service industry in the northeastern region is relatively low; The sub-provincial cities basically maintain a rightward trend, but the magnitude varies, of which Wuhan, Xiamen, Chengdu, the level of high-quality development of modern service industry to improve relatively fast, Dalian, Shenyang, Haerbin and other cities to improve the speed of relatively slow.

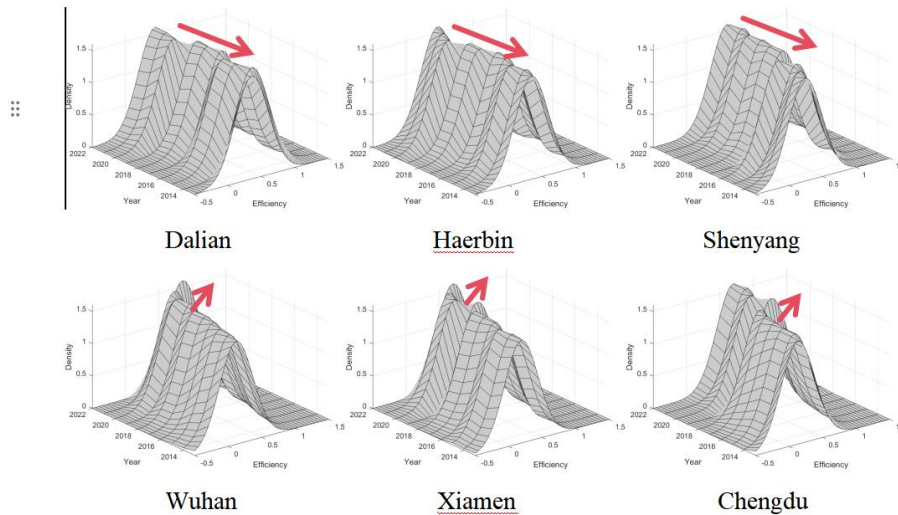


Figure 3. Dynamic Evolutionary Characteristics of High-Quality Development of Modern Service Industry in Sub-provincial Cities

From the perspective of the evolution of the distribution trend of the main peak, the height of the main peak of each city rises during the sample period, indicating that the synergy of the development of the modern service industry is gradually increasing, and the absolute difference is gradually narrowing as a whole. From the perspective of distribution extension, there is a long trailing tail on the right side of the distribution map of the level of high-quality development of the modern service industry, which indicates that the level of high-quality development of the modern service industry in each city is at a relatively low level as a whole. Finally, from the point of view of polarization phenomenon, all cities show a single-peak pattern, which implies that the level of high-quality development of modern service industry has no obvious polarization characteristics.

VI. CHARACTERISTICS OF SPATIAL DIFFERENCES IN THE HIGH-QUALITY DEVELOPMENT OF MODERN SERVICE INDUSTRIES

From the above descriptive analysis and Kernel density estimation, it can be seen that the high-quality development of modern service industry in each city presents a non-equilibrium situation, and the Dagum Gini coefficient is used to further analyze the size of spatial differences in the level of high-quality development of the modern service industry, as well as its sources and contributions. In order to better examine the regional characteristics of the high-quality development of modern service industry and enhance the comparability, this paper further subdivided the selected 15 sub-provincial cities into four geographic regions, namely, Northeastern region, Eastern region, Central region and Western region, according to China's geographic subdivisions to measure and analyze the high-quality development of modern service industry. The Northeastern region includes Dalian, Haerbin, Changchun and Shenyang; the Eastern region includes Shenzhen, Guangzhou, Xiamen, Qingdao, Ningbo, Nanjing, Jinan and Hangzhou; the Central region includes Wuhan; and the Western region includes Xi'an and Chengdu.

A. Characterization of spatial differences

1) Overall and intra-regional differences

Table 3 shows the evolution of intra-regional differences in high-quality development of the modern service industry in general and in the four major geographic regions, in which the overall differences in high-quality development of the service industry are large, with the Gini coefficient ranging from 0.083 to 0.177. Among them, the overall Gini coefficient trend is relatively flat, falling from 0.173 to 0.097 during the sample period, maintaining a small fluctuation state, of which the minimum value of 0.083 was reached in 2019. In terms of the size of the intra-regional differences in the high-quality development of the modern service industry, the Central region has the largest intra-regional differences, with a mean value of 0.096; the Western region has the smallest intra-regional differences, with a mean value of 0.019. The regions as a whole showed different degrees of downward trends, indicating that regional synergy in the development of the modern service industry has been gradually increasing in recent years.

Table 3. Evolution of high-quality development of modern services in four geographic regions in general and intra-regional differences

Year	Overall Differences	Intra-regional Differences			
		Northeastern Region	Eastern Region	Central Region	Western Region
2013	0.173	0.118	0.120	0.133	0.000
2014	0.177	0.149	0.089	0.134	0.000
2015	0.136	0.072	0.127	0.114	0.000
2016	0.109	0.063	0.107	0.110	0.000
2017	0.118	0.041	0.151	0.082	0.000
2018	0.094	0.091	0.089	0.069	0.000
2019	0.083	0.016	0.042	0.074	0.000
2020	0.110	0.072	0.082	0.142	0.000
2021	0.108	0.074	0.089	0.000	0.117
2022	0.097	0.000	0.056	0.100	0.073

2) Interregional differences

Table 4 shows the magnitude of changes in interregional differences in the high-quality development of modern services in the four major geographical regions. In terms of inter-regional differences in the high-quality development of the service industry, the difference between the Northeastern and the Western is the largest, with a mean value of 0.289, followed by the Eastern and the Western, with a mean value of 0.181, and the Eastern and the Central regions have the smallest difference of 0.082, which shows that there is a more obvious divergence between the level of high-quality development of the modern service industry in the Eastern and the Western, indicating that the Eastern region has rich resources and advanced technology compared with the western region, which can support the innovation and development of the service industry.

Table 4. Evolution of interregional differences in high-quality development of modern services in four geographic regions

Year	Interregional Differences					
	Northeastern-Eastern	Northeastern-Central	Northeastern-Western	Eastern-Central	Eastern-Western	Central-Western
2013	0.180	0.241	0.414	0.162	0.285	0.200
2014	0.166	0.223	0.353	0.138	0.245	0.177
2015	0.130	0.140	0.299	0.133	0.215	0.200
2016	0.094	0.111	0.186	0.127	0.169	0.131
2017	0.140	0.124	0.260	0.155	0.176	0.146
2018	0.103	0.106	0.191	0.091	0.156	0.142
2019	0.097	0.164	0.234	0.081	0.140	0.089
2020	0.084	0.145	0.125	0.137	0.121	0.118
2021	0.094	0.077	0.150	0.093	0.153	0.121
2022	0.142	0.187	0.229	0.097	0.104	0.109

B. Sources of variances and contributions

Table 5 reflects the sources of spatial differences in the contribution of high-quality development of modern services in the four major geographic regions. Inter-regional contribution to the spatial difference in the high-quality development of modern service industry is the largest, with an average contribution of 0.063, followed by intra-regional, with an average contribution of 0.034, and hypervariable density is the smallest, with an average contribution of 0.024. All three show small fluctuations, and the trend is smooth, with inter-regional differences being the main source of spatial differences. The inter-regional hypervariable density contribution implies that the cross term between each geographic region is an important reason for the unbalanced character of the high-quality development of the modern service industry. To sum up, there is a more obvious differentiation phenomenon in the development of the service industry in each geographic region, so the lagging regions should be promoted as soon as possible to take the road of differentiated high-quality development of the service industry, and to enhance the coordinated linkage of the development of the service industry among regions.

Year	Contribute		
	inter-regional	intra-regional	Hypervariable Density
2013	0.046	0.107	0.020
2014	0.049	0.108	0.020
2015	0.043	0.064	0.029
2016	0.038	0.033	0.038
2017	0.028	0.068	0.022
2018	0.028	0.032	0.034
2019	0.017	0.062	0.004
2020	0.035	0.046	0.029
2021	0.031	0.050	0.026
2022	0.023	0.059	0.015
average value	0.034	0.063	0.024

Table 5. Contribution of spatial differences in the high-quality development of modern services in four geographic regions.

VII. DISCUSSION OF RESULTS

Firstly, it can be concluded from the trend of the comprehensive index change that all 15 sub-provincial cities are in an upward trend during the 10-year period, but there are large differences in the development between the cities, among which Wuhan has the largest increase, and the difference between the comprehensive index in 2013 and 2022 is 0.733, followed by Chengdu and Hangzhou, with an increase of 0.569 and 0.551, Dalian, Haerbin, and Shenzhen had the smallest increases, with the difference between the 2013 and 2022 composite indices being 0.086, 0.134, and 0.182, respectively.

Dalian, Haerbin, the composite index rose less, indicating that the development of the service industry is slower, the main reason is that as a city in the Northeastern, its pillar industries are mainly based on heavy industry and manufacturing industry, which affects the agglomeration and development of the service industry to a certain extent, and it should make full use of the strong manufacturing base to promote the deep integration of the service industry and manufacturing industry, and to drive the rapid development of the service industry. While Shenzhen's composite index rose only 0.182, as an economically developed first-tier region, it attaches great importance to the development of high-tech industries in order to build an innovative city, while neglecting the development of the service industry. Wuhan, Chengdu and Hangzhou have the largest increase in the composite index of high-quality development because all three cities are located in the Yangtze River Economic Belt, an important economic region. Wuhan's service industries, such as finance, logistics, tourism and cultural and creative industries, are developing rapidly, while Chengdu attracts a large number of consumers with its unique leisure and culinary cultures, Hangzhou has also made remarkable achievements in the field of e-commerce, Internet finance and other modern service industries, and these diversified and characterized service industry development paths have injected new impetus into the high-quality development of the service industry in these cities.

Secondly, it can be concluded from the dynamic evolution characteristics of Kernel density estimation that the rightward trend of each city is different in magnitude, among which Wuhan, Xiamen and Chengdu have a larger rightward trend and the level of high-quality development of modern service industry is relatively fast, and Dalian, Shenyang and Haerbin have a smaller rightward trend and a relatively slower rate of improvement. This result coincides with the previous findings on the trend of the service industry composite index, indicating that promoting the high-speed development of the service industry is the next focus of the cities in the Northeastern region. However, the height of the main peak in the dynamic evolution characteristics graph of each city shows a rising trend, so the inter-regional differences in the high-quality development of the modern service industry are gradually narrowing, which helps to promote the coordinated development of the regional economy.

Thirdly, from the Dagum Gini coefficient analysis of the magnitude of spatial differences and their sources and contributions, it can be concluded that the overall Gini coefficient of the 15 sub-provincial cities has decreased from 0.173 to 0.097, with a downward trend of 0.076, indicating that regional synergy in the high-quality development of the modern service industry is being gradually strengthened. This research result also coincides with the conclusion of the previous dynamic evolution characteristics map, indicating that the service industry is developing synergistically in all regions. Meanwhile, according to the division of the country's four major geographic regions, it can be found that the level of high-quality development of the modern service industry is divided between the Eastern and Western regions, and the mean value of the inter-regional difference is 0.289, which is mainly due to the fact that the eastern region has a relatively high level of economic development, which

provides more space for the development of the service industry. And the degree of openness is also relatively high compared to the western region, which can attract more foreign investment and advanced technology and promote the development of the service industry.

VIII. CONCLUSIONS AND IMPLICATIONS OF THE STUDY

A. *Main Results*

This paper constructs an evaluation index system for the high-quality development of modern service industry based on the four dimensions of development efficiency, structural optimization, innovation agglomeration, and industrial scale, and accordingly measures the comprehensive index for the high-quality development of modern service industry of 15 sub-provincial cities in the country from 2013 to 2022, and carries out a description of the change trend, a regional comparison, and an analysis of the advantages and short boards. The evolutionary trend of high-quality development of the service industry in each city is portrayed, and spatial differences in the level of high-quality development of the service industry in the four major geographic regions and their sources are revealed, leading to the following conclusions:

1) As a whole, the level of high-quality development of modern service industry of each city has been in a state of continuous development during 2013-2022 and is in a slow upward trend, but there are obvious differences between cities, and the difference in the comprehensive index is as follows: Wuhan > Chengdu > Hangzhou > Xiamen > Qingdao > Guangzhou > Nanjing > Jinan > Changchun > Ningbo > Shenyang > Xi'an > Shenzhen > Haerbin > Dalian, and the level of high-quality development of the modern service industry in each city is affected by the market demand, industrial structural adjustment, and the uncertainties facing the world economic development. From the perspective of the first-level indicators, the values of the four indicators fluctuate greatly, the industry scale indicator is at a lower level, with an average value of 0.381, but in the long run, it helps the healthy development of the industry; the structural optimization indicator as a whole is at a higher level, with an average value of 0.825, and occupies a favorable position in the market.

2) The results of Kernel density estimation show that the level of high-quality development of modern service industry in each city shows the trend of right-shift-left-shift-right-shift, and all of them have experienced the fluctuating trend of "rising-declining-rising", and the overall level of development is relatively low, but it is in the process of rising; the distribution of each city basically maintains the trend of right-shift, but the magnitude is not the same, and there is a long trailing tail in the right side; The height of the main peak of each city rises, the synergy of development gradually increases, and the absolute difference gradually narrows; at the same time, each city exhibits a single-peak pattern, and the level of high-quality development of the modern service industry has no obvious polarization characteristics.

3) From the perspective of the Dagum Gini coefficient, the overall Gini coefficient of the level of high-quality development of the modern service industry in the 15 sub-provincial cities has a relatively flat trend, and in terms of the size of intra-regional differences in the high-quality development of the service industry, intra-regional differences are largest in the Northeastern region, and intra-regional differences in the Eastern region are smaller. At the same time, the spatial imbalance between regions is still aggravating, and there is a more obvious divergence in the level of high-quality development of the service industry between the Eastern and Western regions. The Gini coefficient decomposition shows that the spatial imbalance problem between regions is the main cause of the overall differences, the secondary cause is the spatial imbalance problem within the four major regions, and the hypervariable density contributes the least to the overall differences.

B. *Revelations*

First of all, the government should introduce a series of policies and measures conducive to the development of the service industry, for the service industry development is relatively lagging behind the city, you can put forward more preferential tax and financial support policies, to attract more capital and talent inflow, at the same time, the sub-provincial cities should be based on their own service industry development of the actual situation and characteristics of the development of a differentiated strategy; Secondly, to reduce the cost of operation of the service industry enterprises to stimulate the vitality of the market. Secondly, reduce the operating costs of service industry enterprises, stimulate market vitality, accelerate the internal structural adjustment of the service industry, and promote the transformation of traditional service industry to modern service industry, so as to promote the high-quality development of the modern service industry in sub-provincial cities; and finally, strengthen the investment in the development of the service industry, reasonably allocate resources to ensure that factors such as the technology and capital required for the development of the service industry can be effectively

configured, and to promote the technological innovation and industrial upgrading of the modern service industry. Through the rational allocation of resources, the differences between regions will be narrowed, a new development pattern will be constructed, and high-quality development will be promoted.

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